Quantified Carbon

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Making a Difference?

A CASE STUDY OF CONTRACTS FOR DIFFERENCE IN THE UK AND THEIR IMPACT ON THE POWER MARKET, AND WHAT LESSONS CAN BE LEARNED FROM A SWEDISH PERSPECTIVE

This report was prepared by Quantified Carbon on behalf of Svenskt Näringsliv.

SVENSKT NÄRINGSLIV

Executive summary

- **Historical analysis of the UK power market with regards to the CfD scheme shows** that power prices would be 13 €/MWh higher if all CfD-based capacity was removed, which can be compared to 10 €/MWh of estimated CfD cost for consumers in 2025. Grid carbon intensity in the grid has decreased with 43% since the CfD start, however, this can also be attributed to the decommissioning of coal. Regarding coupling, the UK power prices is still correlated to the gas prices, with 76% coupling in 2025.
- **The UK scheme proves that the concept works,** and it is delivering on the intended goal of rapid build-out of low-carbon capacity, through an ever-evolving auction system. But the current generation-based design insulates contracted generators from market signals, leading to dispatch behaviour that can distort prices and disincentivising participation in the balancing market.
- **The impact on the Swedish power market** from a potential CfD scheme has been evaluated with a market price model. The year 2040 has been studied and it is found that introducing either offshore wind power or new nuclear power has similar potential to lower market prices compared to a reference scenario. Taking the different capture rates into account, the cost of both schemes is similar and lower than the reduction of market prices. Besides the impact on spot prices, several other factors need to be considered. These include the profitability of unsubsidised producers, the potential for adding new demand outtake as well as achieving a balanced long term generation mix.

Preface and delimitation

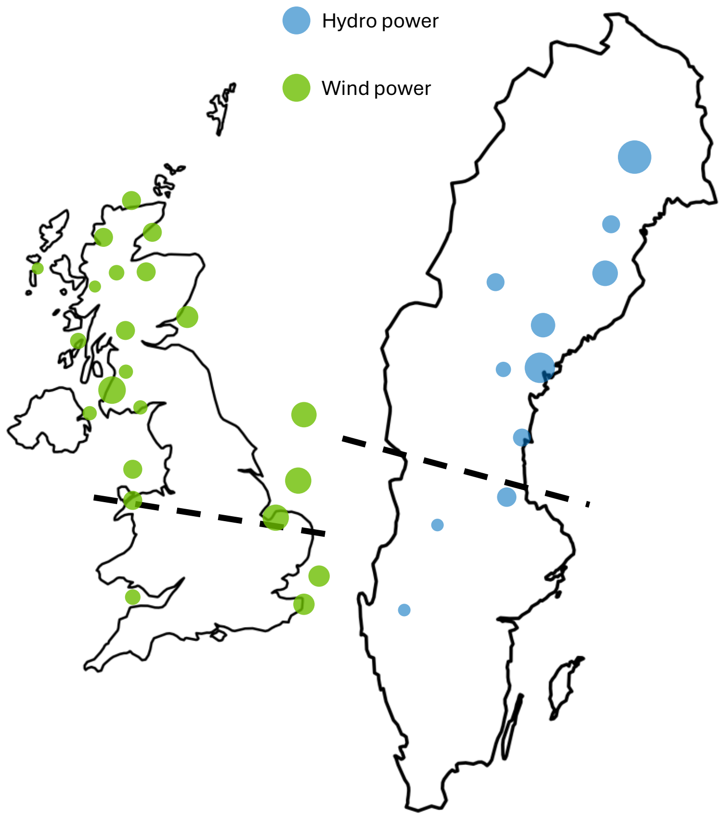
Sweden is facing a growing need for new electricity generation as industry and transport undergo electrification. While onshore wind power has been a key technology in expanding the system to date, the pace and scale of its future deployment are potentially constrained by land-use conflicts, permitting processes and other conflicting interests. And the share of onshore wind in the Swedish power system might be limited by planability requirements and unattractive investment conditions.

In light of this, nuclear power and offshore wind are highlighted as complementary pillars of a future power system: the scalability of offshore wind, combined with the dispatchability and system-stabilising qualities of nuclear power, make both natural candidates. A common feature of both technologies is that, at present, neither is competitive on purely market-based terms. To facilitate a build-out, market intervention is required and Contracts for Difference (CfDs) are frequently cited as an effective mechanism. CfDs are state-backed price hedging tools, used to reduce the risk for developers and drive down cost of capital. Throughout Europe, many countries have launched CfD schemes, among which the UK is one of the countries that has done it most extensively.

Quantified Carbon was tasked by Svenskt Näringsliv to write a case study about UK's CfD scheme and explore how a potential Swedish scheme would impact the Swedish power market. The UK offers a unique case for comparison. For over a decade the country has applied CfDs across many technologies - solar, onshore wind, offshore wind, biomass and nuclear - and shares several structural similarities with Sweden: abundant resources in the north, major population centres in the south, and transmission bottlenecks that drive similar system challenges and policy debates (see graph).

Svenskt Näringsliv's and Quantified Carbon's aim for this report is to increase the knowledge of CfDs in general and facilitate a discussion of the potential use of CfDs in Sweden. This report further aims to shed light on a good comparison, rather than to act as a complete guide for the implementation of a CfD scheme in Sweden. Prices, volatility, and gas market coupling were specific topics chosen to analyse in the UK. On the Swedish analysis, demand outtake and broader power system implications were also included.

To make this report focused and concise, certain delimitations were made. Firstly, when analysing the CfD programme in the UK, focus has been put on offshore wind, onshore wind, and solar PV. Advanced smaller technologies and biomass power generation have been excluded, since these are less relevant for the discussion of implementing a CfD programme in Sweden. UK CfD-based nuclear has not yet come online for the period analysed. For the historical analysis of the UK CfD programme, the years 2017-2025 were analysed, as these are the years that the programme has supported any significant electricity generation (in 2016 only 6 GWh of CfD-supported solar electricity was generated).



Structure and agenda

In this report, four main analysis topics are covered. First, a relevant background and literature review is presented. Second, a historical analysis is performed for the first 8 years of the UK CfD scheme, investigating the outcomes of the scheme up until the present day. Third, the report presents modelling of the Swedish power system in 2040, with different scenarios based on a potential CfD scheme implementation for offshore wind and nuclear power.

Final conclusions and discussions on CfD designs are presented in the final chapter of the report, with discussion on design choices for Swedish policy makers to consider. Drawing from results in this report as well as literature on the subject, the discussion chapter aims to bring nuance to the design stage for a CfD scheme.

1 **Background**
Explaining the electricity market and CfDs, the rationale behind introducing a CfD scheme, and a literature study on CfD design.

2 **Historical analysis of the UK power system**
Historical review of the UK power market to analyse impacts of the CfD scheme. Modelling the system with/without CfD resources.

3 **Scenarios for potential CfDs in Sweden 2040**
Turning to Sweden and reviewing implications of a potential offshore wind and nuclear CfD scheme in Sweden.

4 **Discussion and conclusions**
Analysing results, referencing the literature study, and discussing the path forward for Sweden

Glossary

Spot price: The industry term for electricity price.

CfD: Contract for difference. A contract between a generator and a government body to ensure the generator revenues according to a pre-determined strike price, used to subsidise clean energy.

Two-sided CfD: A CfD where the generator receives payments from the government body if the reference price (typically the spot price) falls below the strike price, and the government body receives payments from the generator if the reference price rises above the strike price.

AR: Allocation Round. The auction rounds in which projects compete for the UK CfD scheme. Seven Allocation Rounds have been held, with the result of AR7 being published in early 2026, and the submission to AR8 is currently ongoing. Currently, Allocation Rounds are being held annually.

LCCC: Low Carbon Contracts Company. Private company, owned by Department for Energy Security and Net Zero, which administers contracts awarded in the CfD scheme.

BEIS: Department of Business, Energy & Industrial Strategy (UK).

DESNZ: Department of Energy Security and Net Zero (UK).

RO: Renewables Obligation. A former clean power support scheme in the UK. Similar to "elcertifikatsystemet" in Sweden.

TSO: Transmission System Operator. The governmental body that is responsible for operating and maintaining the transmission grid.

SvK: Svenska kraftnät, the Swedish TSO.

Derating capacity factor: "Effektbidrag" in Swedish. An estimate of what amount of a new generator's nominal capacity can be used by the grid operator to offer new demand capacity. A hypothetical derating capacity factor of 50% means that a new power plant of 100 MW will allow for 50 MW additional demand to connect to the grid.

Box plots: A statistical graph to display a distribution. The box is made up of the 25%- and 75% percentiles of the distribution. The whiskers represent the 5%- and 95% percentiles of the distribution. Median is displayed as a line in the box, and the average (mean) is displayed as a dot.

SRMC: Short-run marginal cost - the cost for production of power from gas plants, a proxy for the marginal prices set by gas power generators. Considers gas price, carbon cost, and plant efficiency.

1

Background

The electricity market

To understand CfDs, one first needs to understand the electricity market

The spot market

Before turning to how a CfD works, it is important to understand the mechanisms of the underlying electricity market, the “spot market”.

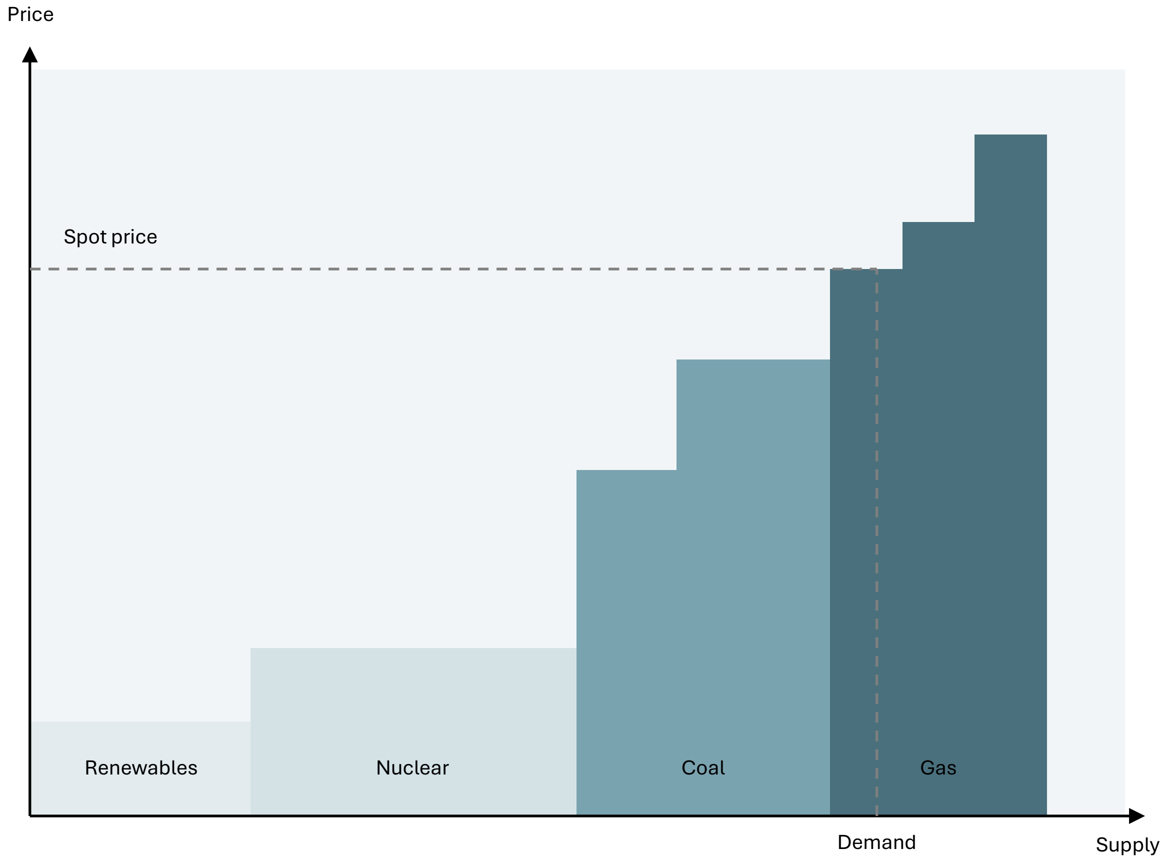
The spot market can be seen as a supply and demand curve. Supply is electricity generators that bid in with their capacity at as competitive prices as possible. All supply bids are sorted by price in ascending order. Demand is the total electricity need (industries, heating, civil, etc.).

Spot price is where the supply and demand curves meet. By design, the spot price is defined by the price of the last required supply bid. Furthermore, the spot market is, like many other financial markets, designed with marginal pricing. That means that all sellers and buyers will receive the same price – the spot price.

To lower the spot price is the same thing to push the most expensive bid out of the merit order. In the graph to the right, more renewable or nuclear power, i.e., a wider box, would push the gas bids past the demand line, instead letting the lower coal bids set the price.

Auctions on the spot market are held the day before delivery, one auction for every quarter hour. For many CfDs the spot price is the base for remuneration. What the government pays to (or gets from) generators is dependent on that period’s spot prices.

The Merit Order (€/MWh)



Crash course in CfDs

CfDs are used to decrease project cost of capital and are chosen as the EU standard

Understanding CfDs

CfDs are a financial tool used to increase the deployment of clean power. Instead of only receiving payments from the spot market, CfDs provide price certainty to generators based on a strike price (explained further below). At a fundamental economic level, CfDs reduce exposure to uncertain market prices. Subsequently, developers and lenders see lower risks, which reduces the cost of capital for their projects. Putting it another way: CfDs are tools to enable clean power projects that would not have been built purely on a market basis.

The European go-to for state support schemes for clean power is CfDs. CfD auction rounds, where clean power developers bid with their projects and compete for contracts, are held in 10 European countries, with more than 200 auctions closed to date[1]. The design of CfDs varies between the European countries that have implemented them. In late 2023, the European Council and Parliament agreed that CfDs, more specifically a two-sided CfD, would be the standard for direct price support schemes[2].

In a more technical perspective, a conventional CfD is a contract between a government body and a clean power project. If the spot price falls below the strike price, the government body pays the difference back to the generator (top-up). If the spot price is above the strike price, the generator instead pays the government body the difference (clawback). The clawback mechanism in high price periods is why it is called a "two-sided" CfD. As a results of these cashflows, the generator will receive the strike price for all electricity generated.

A conventional two-sided CfD is what has been used in the UK. But there are also other possible designs for a CfD. One of the main choices being whether to connect cashflows to actual generation or expected generation. The differences between the two approaches will be highlighted further in the literature review.

Conventional two-sided CfD during 24 hours (€/MWh)

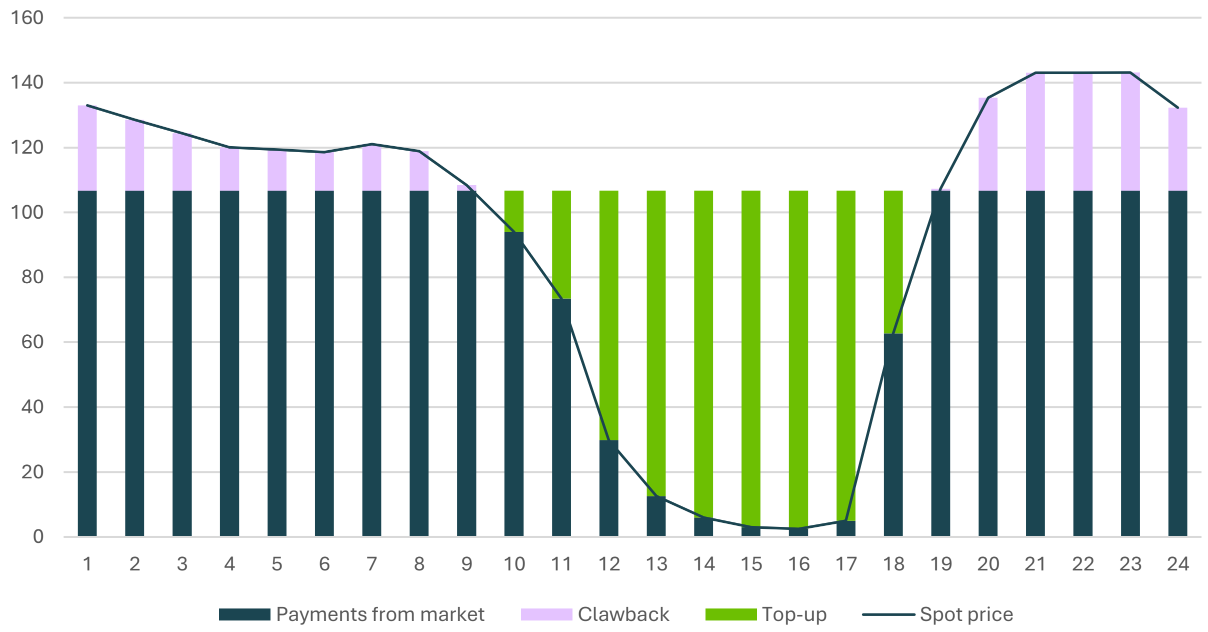


Figure 1: Example of 24 hours cashflows for a (two-sided) CfD with a strike price of 107 €/MWh (last UK offshore auction price). Clawbacks occur when cashflows are going from generator to the government body, when the spot price is higher than the reference price. Top-ups occur when reference prices are lower than the strike price. Reference prices from UK spot prices 2026-08-08. The graph above assumes a baseload production from the generator for simplicity.

In the UK context

The UK's support scheme has been incrementally adapted over the years

Background to the UK CfD scheme

Multiple programmes have been used to incentivise clean power in the UK. The Renewables Obligation (RO) scheme encouraged producers to include more generation from renewable sources[1], similar to the Swedish ”elcertifikat” system. RO was opened in 2002 and closed for new registration in 2017. The Feed-in Tariff (FiT) scheme, for smaller clean power installations, was active between 2010-2019[2].

Contracts for Difference have since become the UK's main subsidy mechanism. Introduced in 2013, the scheme hosts Auction Rounds (AR) in which developers bid with a requested strike price and project size. Successful bidders sign their contract with the Low Carbon Contracts Company (LCCC), a government-owned counterparty established to hold and settle CfDs on behalf of the state. The scheme involves a two-sided CfD which has been adapted, and continues to evolve, to best fit the UK energy sector:

- **Technology-specific 'pots' each have a maximum allowed strike price bid**, with the most competitive bids accepted until a pot-specific budget is reached. "Less established" technologies, for example, may be offered a higher "Administrative Strike Price" ceiling.
- **Developers must meet milestone requirements** to ensure that the winning projects are delivered within a reasonable timeframe[3].
- **Contracts have a fixed period for remuneration**, which was increased from 15 to 20 years for some technologies in the most recent AR.
- **Payments are calculated based on market reference prices**, which are different for baseload and intermittent technologies[4].
- **Negative price hours do not yield payouts** following a series of incremental policy changes.
- **Strike prices are indexed to consumer price inflation**, though this does not protect from technology-specific cost inflation, which can lead to unattractive prices (as seen in AR5)[5].

A Review of Electricity Market Arrangements (REMA) is held regularly in order to assess the current system, including CfDs. Recent iterations consider fundamentally changing the CfD design, but opt to avoid substantial changes until consumer benefits are shown to outweigh incurred costs, risk and disruptions[6].

UK CfD scheme history

	FIDeR	2013	Bespoke contracts for 8 large projects before the first AR.
	AR1	14'/15'	
Suspend payments after 6 consecutive negative price hours.	**AR2**	17'	
	AR3	19'	
	AR4	21'/22'	Suspended payments for all negative price hours.
No offshore wind bids due to low strike price. Change to annual rounds.	**AR5**	23'	
	AR6	24'	
	AR6/7/7a	25'/26'	Dedicated round for offshore/floating wind. CfD contract length increased from 15 to 20 years for wind & solar.

Sources: [1] Ofgem, [2] Ofgem, [3] LCCC, [4] LCCC, [5] Energy UK, [6] UK Gov.

Objectives of a CfD scheme

Core objectives for CfD scheme in Sweden could be different than they were in UK

Decided objectives UK CfD scheme

Electricity market reforms were pursued in the UK with the objective of[1]:

CfD objectives

- **Maintaining a secure, diversified supply** of electricity following decommissioning of coal and ageing nuclear plants and in an increasingly intermittent, weather-dependent fleet of generators;
- **Decarbonising electricity generation**, such that emissions targets are met;
- **Meeting the steep increase in electricity demand** expected due to electrification;
- And **minimising costs for consumers**.

The government acknowledged that the ambitious build out of low carbon capacity needed to attain such goals would be difficult to achieve without investment incentives to level the playing field and reduce risks, and it deduced that CfDs were the most cost-effective support mechanism.

Since the adoption of CfDs, small changes to the scheme have been enacted, largely in service of these original goals. However, limitations and shortcomings of the current framework have been identified and will require more substantial interventions. For example, "deemed" or capacity-based CfDs are being considered as a way to avoid volume risks and improve the efficiency of producers' operation[2]. While major changes to the main CfD scheme are not planned until AR9 at the earliest[3], other policies have been put forward in response to more immediate issues. For example, Wholesale CfDs will be introduced later this year[4], offering existing generators the option to accept a fixed-price contract, with the intention of reducing the link between gas and consumer electricity prices.

Potential objectives SE CfD scheme

In 2024, the Swedish government presented a new vision for the Swedish power market. A planning target of 300 TWh by 2045 was decided upon. If a CfD scheme in Sweden were to be introduced, it is likely that it would be related to these objectives. The main objectives included in the new target are articulated below[5].

Potential CfD objectives

- **Enable 300 TWh of demand** to be connected by 2045.
- Planning for the Swedish electricity system must **create the conditions** necessary to supply the electricity required for increased electrification and **to enable the green transition.**
- The Swedish power system shall have the capability to **provide power** where **demand** is, in a **timely fashion**, and in **sufficient amounts**.
- Unmotivated obstacles in the power system shall be removed to ensure an efficient power market that results in competitive prices.
- Suggesting to give the TSO an overarching responsibility to evaluate where and how much demand is needed to be met with generation.

In comparison with the UK objectives for their CfD scheme, some of the topics are irrelevant in Sweden.

- Decarbonising electricity generation is already achieved with the Swedish generation mix of renewables, hydro power and nuclear power.

[1] Gov. UK, [2] Gov. UK, [3] Gov. UK, [4] Gov. UK, [5] Swedish Government

Recent neighbouring CfD rounds

Several Offshore CfDs have been auctioned in northern Europe recently

Norway

- Closed 1.5 GW Offshore round in 2024 at 105 €/MWh[3].
- Two-sided CfD with a cap of €1.9bn maximum support.

Sweden

- Has investigated CfDs for Nuclear, as one of three support pillars in the “Dillén report”.
- 72 €/MWh[5] strike price suggested for a financial Nuclear CfDs in the report.

Denmark

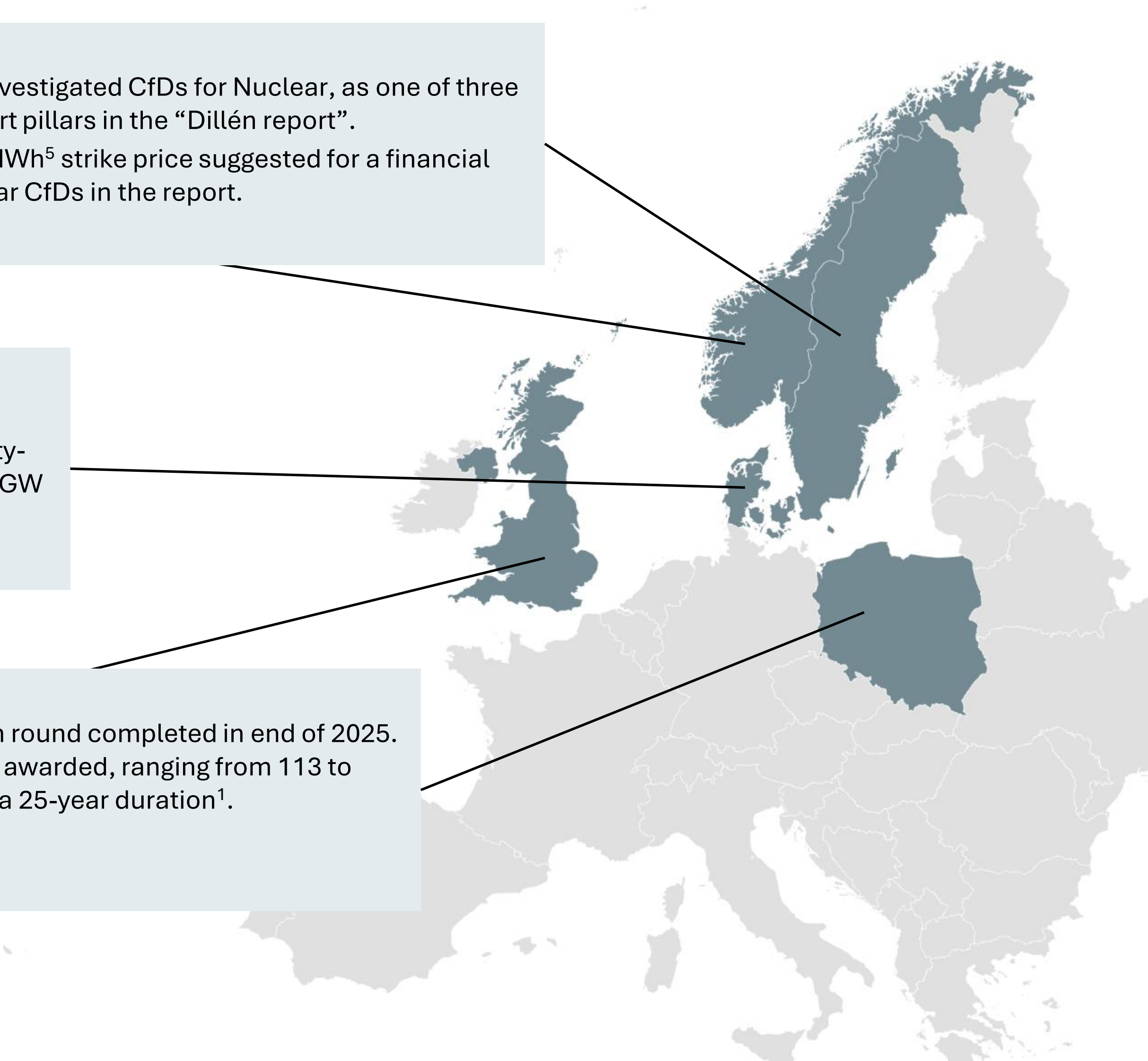
- Failed Offshore round in 2024 with no bids.
- 2026 Offshore round, with two-sided, capability-based CfD for 20 years won by Vattenfall[2]. 1.8 GW awarded with strike prices between 67 and 73 €/MWh.

UK

- AR7 closed at 107 €/MWh[4].
- Seventh round since 2015.
- Conventional two-way CfD.

Poland

- First ever auction round completed in end of 2025. 3.4 GW Offshore awarded, ranging from 113 to 117 €/MWh with a 25-year duration[1].



[1] Pexapark, [2] WindEurope, [3] Sintef, [4] Gov UK, [5] Dillén

Literature study

To get more in-depth understanding of CfDs, the report reviewed relevant literature

Energiforsk highlights CfDs in a Swedish context in the 2024 study "Contracts for Difference (CfD) in the Swedish Electricity Market". The study highlights CfDs as a tool for risk management as there currently is a lack of market-based hedging options. Furthermore, the study highlights four key design choices to consider in a Swedish context: geographic-specificity, technology-specificity, designing CfDs to ensure cost reflective market behaviour, and risk sharing. Under the technology-specificity design choice, the report highlights that CfDs are *"mainly relevant to technologies offering substantive advantages to the power system but lack profitability in the market, exemplified by nuclear and offshore wind power."*

Another prominent study on CfD design was written by Schlecht et al. in 2024. According to Schlecht et al. a "conventional" CfD, such as those implemented in the UK, poses three main challenges: 1) a "produce-and-forget" phenomenon, where generators are shielded from price signals, 2) distortions on secondary markets, such as intraday and balancing markets and 3) a shortcoming of addressing generators' volume risks. Typical fixes to challenges with a conventional two-sided CfD are also discussed. The solution of suspending top-up payments during negative price hours adds revenue risk to generators, who cannot control the frequency of such prices. The solution of a longer reference price period – for example yearly average spot prices instead of daily – could disincentivise generators to act efficiently on wholesale markets since the cashflow from the CfD is pre-determined, but still dependent on generators' output volume.

This study subsequently introduces the concept of a generation-independent "financial CfD" which proposes fixed hourly remuneration for CfDs. In a financial CfD, projects receive hourly financial obligations based on a reference plant within the same geography and resource type while receiving the wholesale revenue for themselves. Such a design incentivises efficient market behaviour while still mitigating revenue risk for generators. The paper mentions the idea of having a technology neutral CfD scheme, with identical base profile payment obligations for all generators. This would introduce cross-technological competition but with notably more basis risk for wind and solar generators, who will have a bigger challenge to meet the baseload payment obligations every hour.

In "Contracts-for-Difference to support renewable energy technologies (…)", Kitzing et al review various design options for CfD, among others the financial CfD approach proposed by Schlecht et al. The authors raise the question of whether a base reference generator is suitable for (technology-specific) RE support schemes, as it increases basis risk, and subsequently investment risk, for wind and solar generators.

In the UK context, Salmon et al (UCL) describe challenges for the UK CfD scheme. Salmon highlights three main challenges for the scheme: 1) lack of locational signals, 2) declining effectiveness of reducing investment risk due to increased number of negative price hours without any revenue, and 3) unwanted impact on wholesale and secondary markets due to generators wanting to maximise generation.

Back in the Swedish context, the Dillén report from 2023 suggests a version of a financial CfD for new Nuclear. New nuclear will receive remuneration from the spot market based on hourly prices and generation, and then additional remuneration from the government based on the difference between strike price and average annual market price multiplied by expected generation. As in a financial CfD, the support scheme is here disconnected from actual generation. Furthermore, the report suggests two other pillars of support for a new nuclear programme: state loan guarantees and a risk-sharing mechanism.

Energiforsk, Schlecht et al., Kitzing et al. UCL , Dillén

2

Historical analysis of the UK power system

Historical analysis

The UK CfD scheme is heavily dominated by Offshore wind

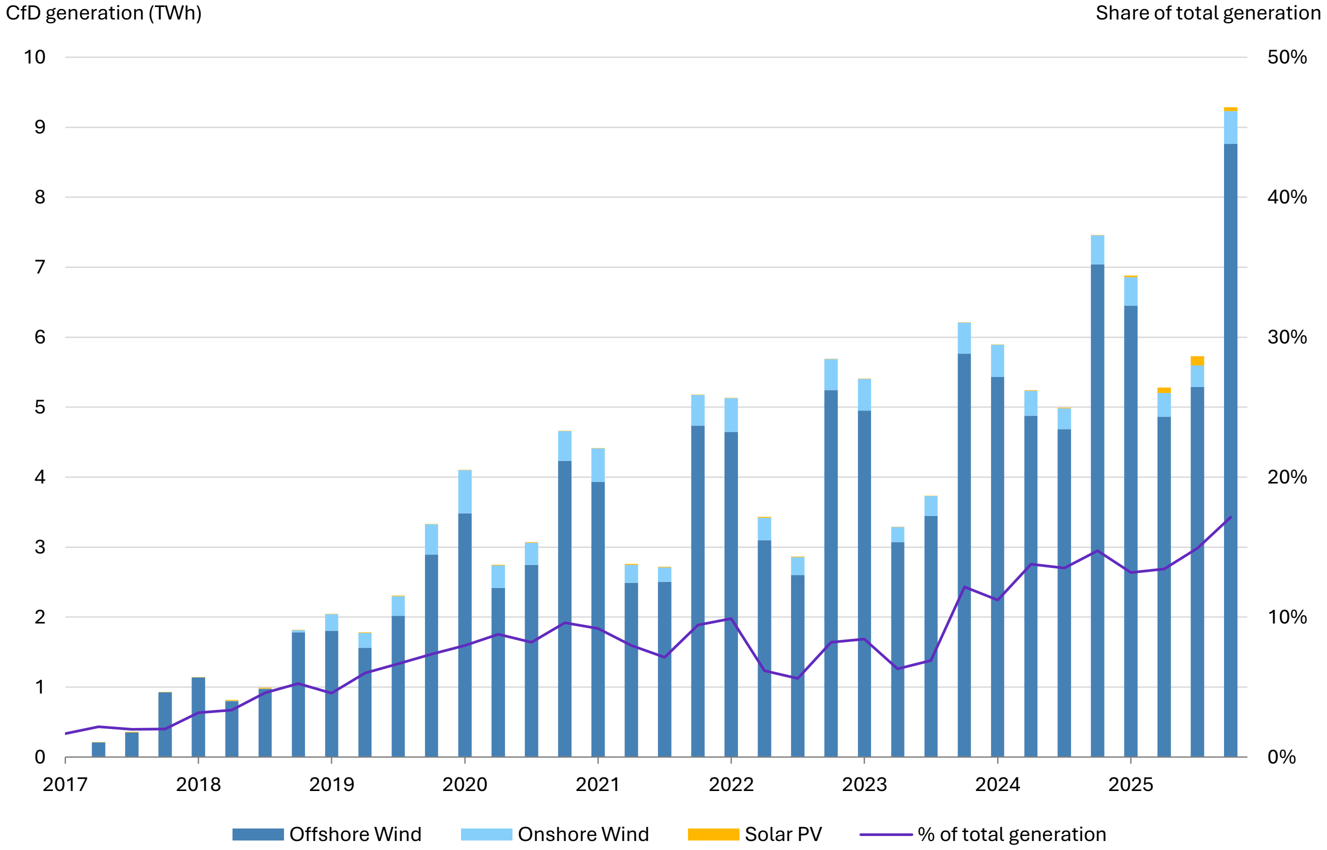
CfD generation has reached 15% of total generation

To get an understanding of the extent of the UK CfD scheme, the report will start off by analysing generation from all projects that have received any support in the scheme. This report focuses on Offshore, Onshore, and Solar PV for the UK, but the CfD scheme has also resulted in other generation, most notably biomass power. While the CfD scheme was initiated in 2013, projects only started to come online in 2017. That is the why the period 2017-2025 was chosen for the analysis.

Since 2017, UK has installed more than 10 GW of operational capacity under CfDs[1]. Offshore wind dominates the mix and will continue to do so: 8.4 GW of new capacity was secured in the last allocation round (AR 7/7a) alone.

CfD projects generated about 17% of UK power in the last quarter of 2025, corresponding to 9 TWh, as shown on the right. On the year in total, 27 TWh from CfD-based projects was generated. A pattern of seasonality in the generation is noticed, with less generation in Q2 and Q3 of most years, corresponding to less windy spring and summer periods.

Quarterly CfD-based generation[1]



[1] Data is gathered from LCCC and REPD.

Historical analysis

Transparent data allows for CfD cost review

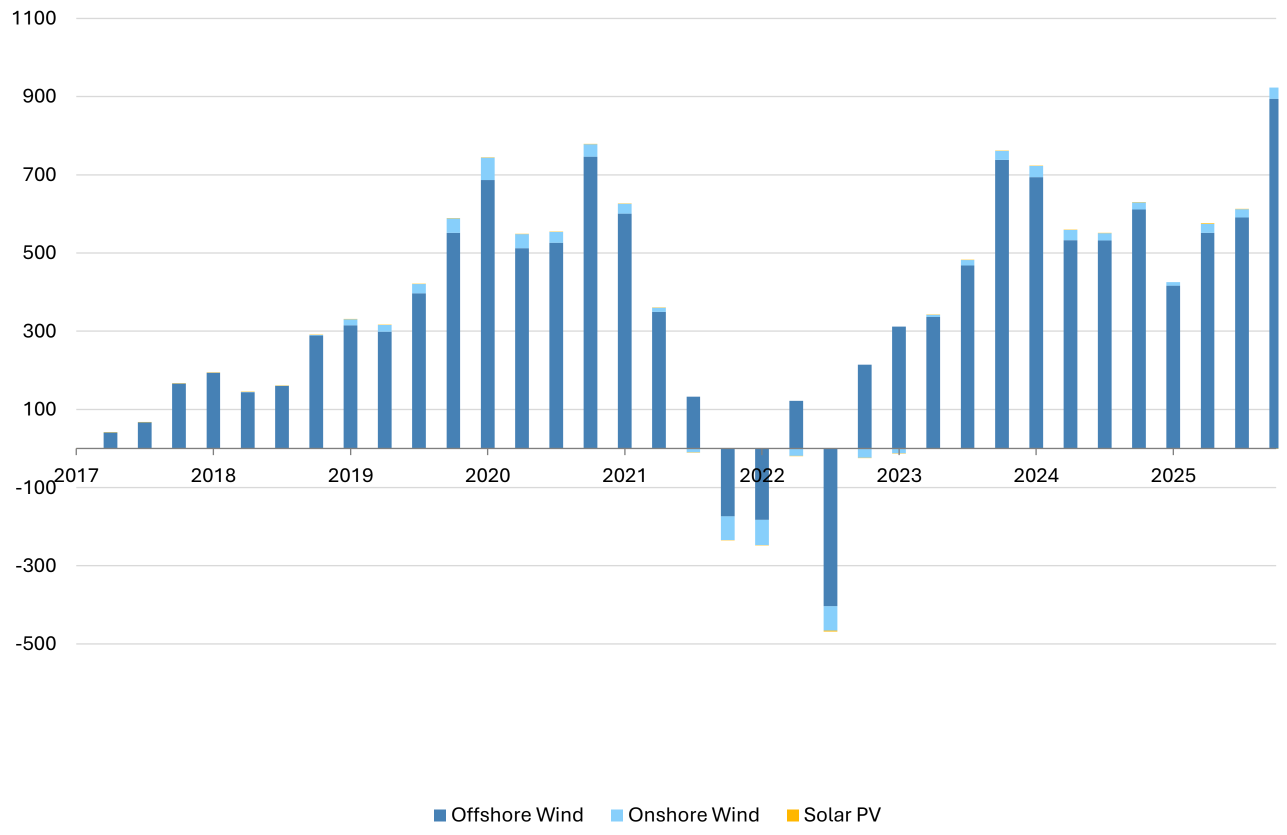
CfD costs and revenues

While the CfD scheme has resulted in significant additional generation, it is also relevant to see what the cost and revenues have been. Since the UK chose a two-sided CfD, costs are incurred when spot prices are lower than strike prices and revenues are collected the spot prices are higher than the strike price. LCCC data is used in the graph on the right, aggregated across all CfD projects. Note that revenues in 2022 are due to the energy crisis, which pushed spot prices far above strike prices, activating the clawback mechanism of the CfDs. By design, the two-way CfD scheme in the UK will provide payments back to consumers in times of extreme high price periods.

The graph displays that offshore wind constitutes the majority of CfD cost. Even with recent additions of onshore and solar PV capacity, roughly 95% of the CfD costs are attributed to offshore projects. Average cost of the scheme over the last three years has been 2.2 € billion per year, inflation adjusted. To put the number in relative terms, by dividing with the annual power demand in the UK, the total cost of the CfD scheme is 10 €/MWh, for Offshore, Onshore and Solar PV. For Offshore alone the cost is 9.6 €/MWh.

In the UK, CfDs are funded by the consumers. Net consumer cost is modest and now positive again, adding almost £40 a year to a typical household bill, and around £180 cumulatively between April 2019 and May 2026[1]. Another thing to highlight when discussing costs is that the CfD scheme has enabled approximately £86 billion of private investment to date[2].

Quarterly CfD-based cost/revenue (million €)[3]



[1] UK Parliament, [2], Energy UK, [3] All prices and costs are inflation adjusted to 2026 price levels.

Historical analysis

Investigating the correlation between gas power cost and power prices

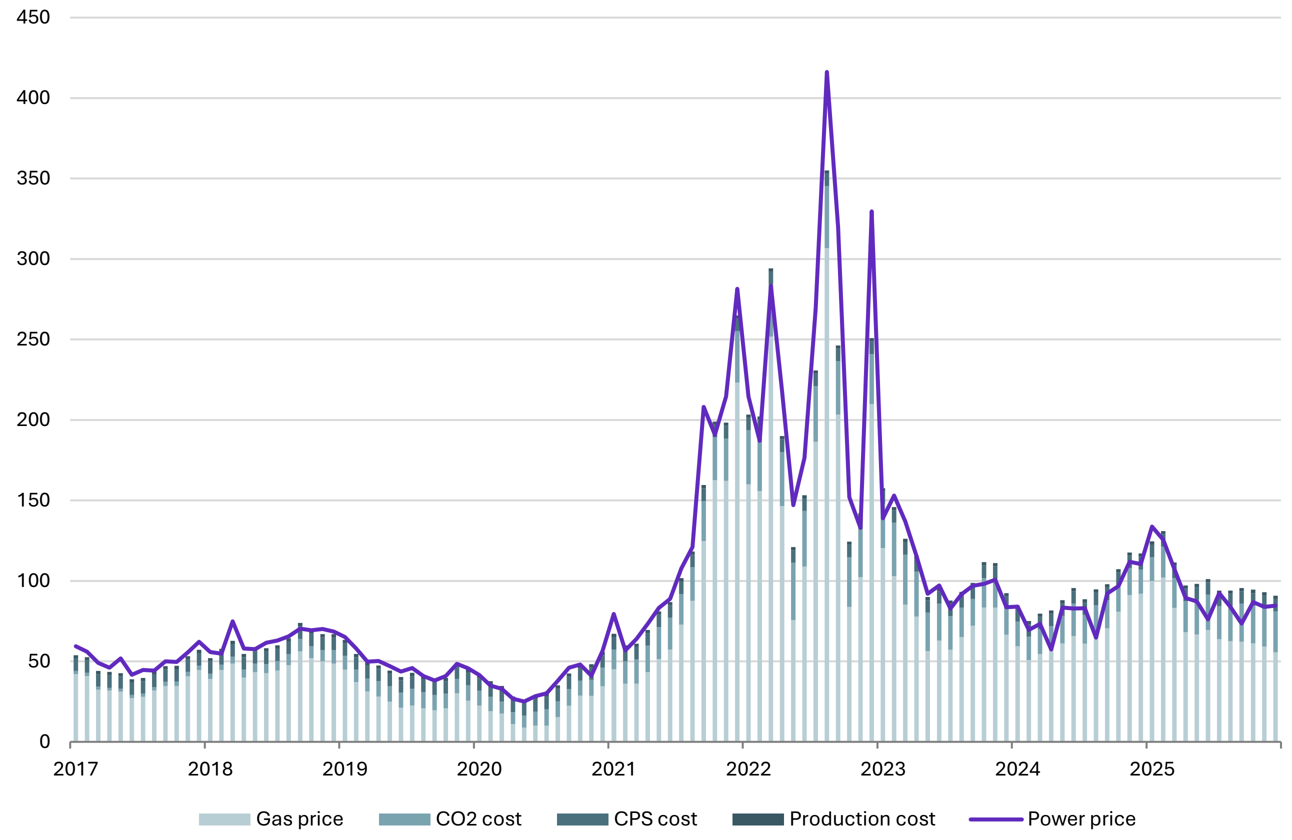
UK power and gas prices coupling

The coupling between UK power prices and gas market prices is a relevant topic to investigate for this report. Gas is, as mentioned when explaining the spot market, far out on the merit order and is often the marginal price setter. To decouple power markets from gas markets is synonymous with pushing gas power bids out of the merit order. In this report, historical power prices and gas prices have been analysed to see what implications the introduction of the UK CfD scheme has had on the coupling between the two markets.

By comparing historic electricity prices to gas production costs (as shown on the right), one can see that the two have been strongly correlated: the spot price is often higher than the gas price, indicating that gas is the price setter in the power market. To compute the gas production cost, the SRMC (short-run marginal cost) was used, taking into consideration daily gas- and CO_2 prices. An estimated average efficiency of 0.5 was assumed for the gas plants.

The historical strong correlation, with power prices hovering just above the marginal production costs of gas softens a bit in 2024 and 2025, however. Monthly power prices start to drop below the gas power marginal costs, indicating that the coupling between the markets in 2025 is lower than in previous years.

Monthly gas power cost and power prices (MWh)[1]



[1] Inspired by Ember, data from Montel. Gas power cost is taking into consideration daily gas prices and CO2 prices, Carbon Price Support (CPS). Average efficiency = 0.5.

Historical analysis

Investigating the correlation between gas power cost and power prices

Computing when a gas sets the power price

The share of spot price hours set by gas prices is another way to review coupling between power prices and gas prices. In the graph on the right, the cost of gas power production was compared to the power price itself. If the power price was higher than the gas power cost, said hour is deemed to be set by gas.

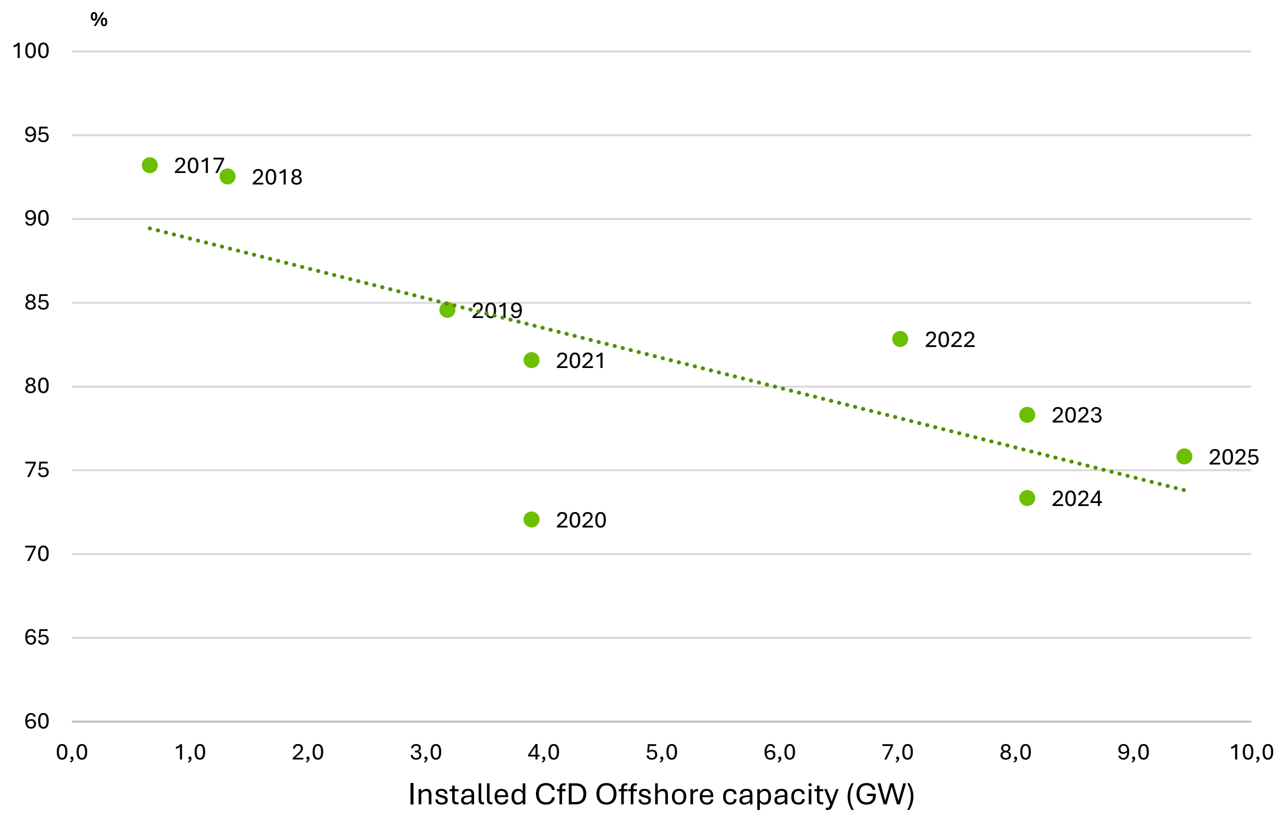
More specifically, the SRMC (short-run marginal cost) was used to compute the gas power production cost. It uses daily gas prices, daily CO_2 prices, and plant efficiency. An error margin factor of 0.95 was introduced to catch hours where SRMC was just above the power price.

$$p_{spot} > \text{SRMC} \cdot 0.95 \rightarrow \text{gas sets the price}$$

This report calculates the share of hours set by gas to 76% in 2025, a decrease from the 2017 when roughly 95% of hours were set by gas. Next to this report's computation, there have been other parties calculating the number of hours set by gas. DESNZ[1] states that the share is reduced to 60% in 2026, while Ed Porter[2] from Modo Energy highlights a share in 2025 of 83%.

There is evidence of some decoupling between gas and power markets, which more technically can be explained by the fact that the expansion of renewables has started to push gas out of the merit order for certain hours. This report does not model what further buildout of clean power will mean for gas coupling, but with purely intermittent production it is difficult to completely remove the correlation to the gas market.

Share of spot price hours set by gas vs. Offshore capacity (%)[3]



[1] Carbon Brief [2] Ed Porter [3] Gas power cost is taking into consideration daily gas/CO2 prices, and CPS. Efficiency = 0.6 to mimic top-of line gas plant (cheapest gas power).

Capacity and generation

Introducing scenarios to evaluate the impact of CfDs on the power market 2025

Scenarios chosen for the modelling

In order to evaluate the impact of the CfD scheme on the current UK power market, the UK power system was modelled in 6 scenarios for the year 2025. Installed and operational capacities of plants granted contracts were extracted from a combination of LCCC and REPD data[1], as plotted in the top right graph. All capacity that was built thanks to CfD, regardless of the contracted share, is included.

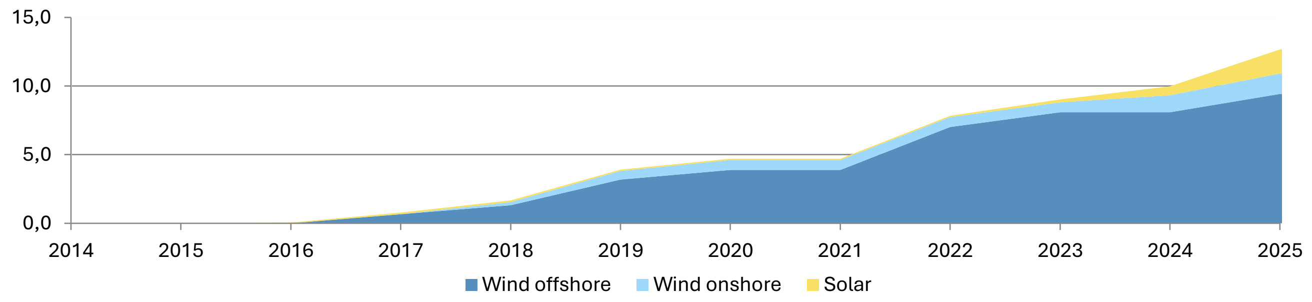
While the first (All CfD) scenario models the current system, the other five systematically remove installed capacity for projects which were granted CfDs.

- **No Solar** excludes all CfD-funded solar PV capacity.
- **No Onshore Wind** excludes all CfD-funded onshore wind capacity.
- **No Offshore Wind** excludes all CfD-funded offshore wind capacity.
- **No Offshore Wind + coal** excludes all CfD-funded offshore wind capacity, while adding back coal capacity. Rationale: Coal capacity might not have been removed, to reduce price shock, had the offshore capacity not come online.
- **No CfD** excludes all CfD-funded solar PV, offshore wind and onshore wind capacity.

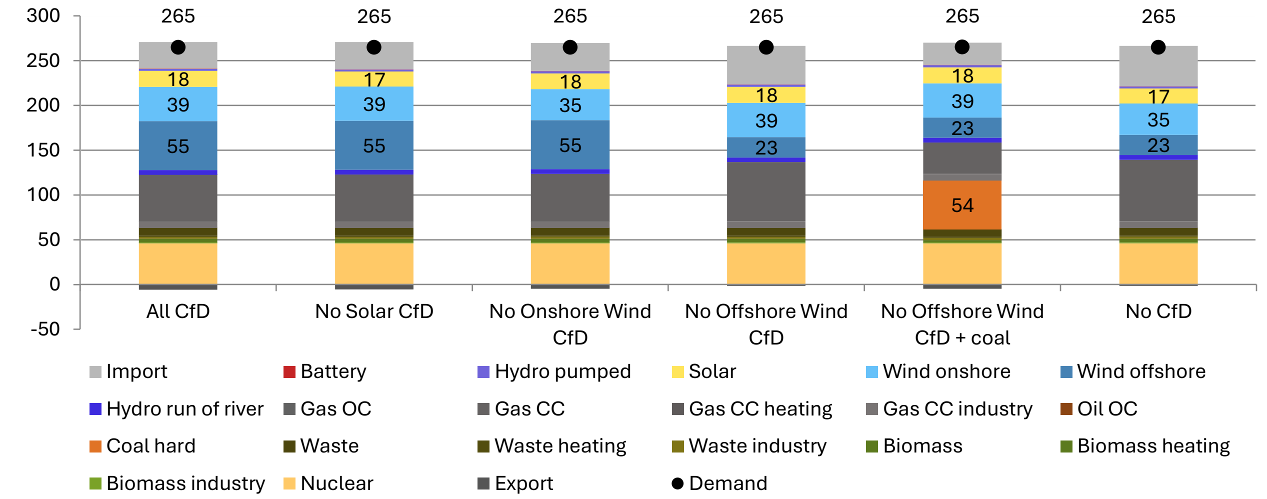
The bottom plot shows the generation, import and export volume for each of the modelled scenarios, using 1991 weather data. It can be used to see the difference between the scenarios in terms of electricity production.

On the next page the results of the modelling regarding power prices are presented.

Total installed CfD-based capacity (MW)



Generation per resource and scenario, 2025 (TWh)



[1] REPD

Prices and volatility

Without CfD-based offshore, UK power prices would be higher and less volatile

Background to the results

Each of the scenarios was modelled over 33 weather years in order to gauge the volatility of prices when exposed to different conditions. All modelling was done on the 2025 system.

Distributions of spot prices over the weather years are shown for each scenario in the form of box plots on the right. Prices are averaged over each quarter year. The length of the box gives the range of prices seen in a typical quarter, while the scattered points mark quarters with extreme prices. For reference, the actual UK mean spot price in 2025 was 94 €/MWh.

Removing all CfD capacity raises the mean price by 13 €/MWh, from 93 to 106 €/MWh. Unsurprisingly, removing subsidised offshore wind makes the biggest impact, raising the mean price by 11 €/MWh.

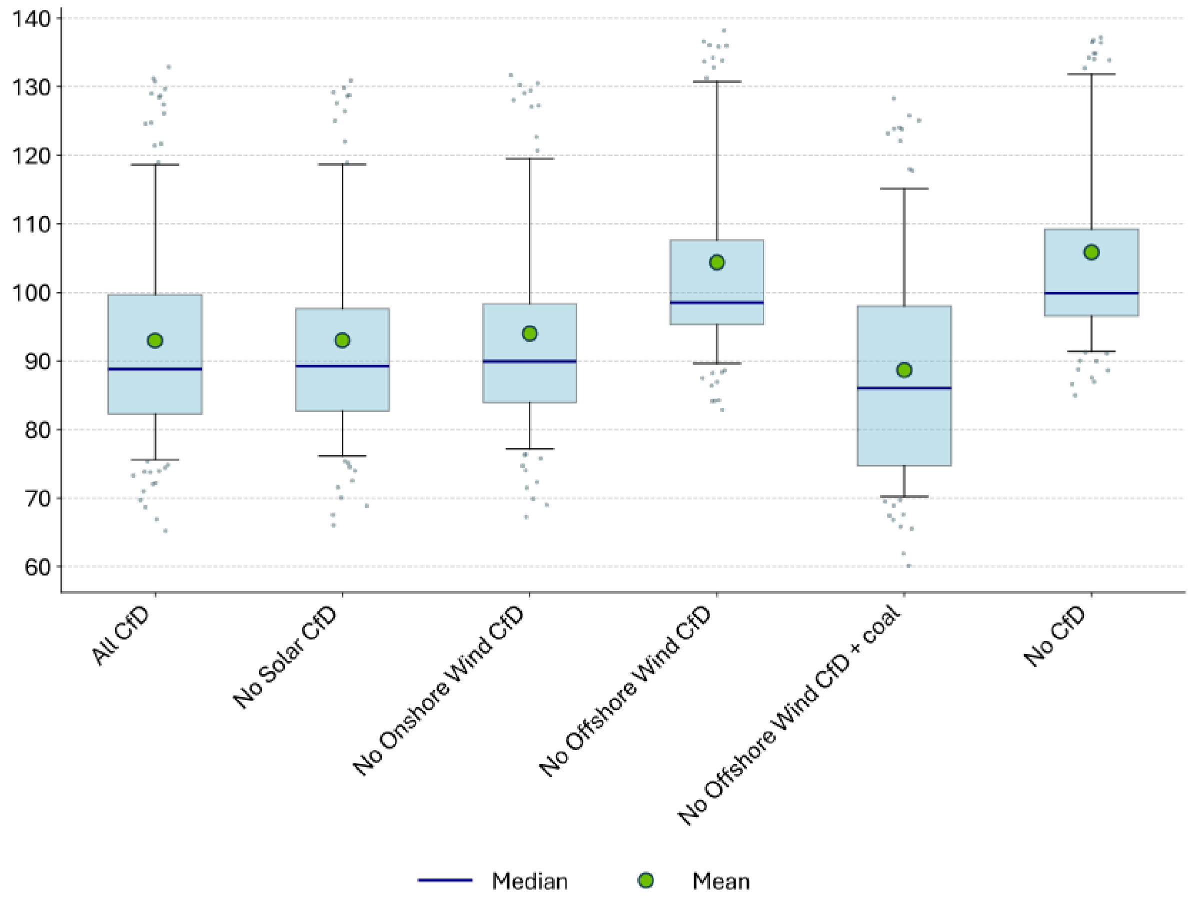
The removal of solar and onshore CfD capacity barely moves the mean price, reflecting their small contracted volumes in 2025.

Keeping coal rather than building subsidised offshore wind actually lowers the average price, down to 88.7 €/MWh, though this, of course, leads to greater emissions.

In general, higher prices come with a tighter distribution: with less offshore wind, gas sets the price more often and the weather-driven spread falls.

The addition of coal does introduce some spread, since it is priced at a similar level to gas, meaning different quarters alternate in terms of which one sets the price.

Modelled spot prices per scenario, 2025 (€/MWh)



[1] The boxes represent the spread of yearly average prices of 33 different weather years.

Historical analysis

The UK CfD scheme has been impactful, but gas correlation remains in the market

Breaking down the numbers

In summary, the adoption of CfDs in the UK energy sector has been broadly successful, delivering large volumes of low-carbon generation. The scheme has resulted in 12 GW of new capacity installed, amounting to 27 TWh of generation in 2025, highly driven by Offshore capacity and generation.

On decarbonisation, the UK's grid carbon intensity fell from 303 to 174 gCO_2/kWh between 2017 and 2025. This is largely driven by the growth of renewable energy capacity, CfD-based and other, but also the phase-out of coal-fired generation.

Regarding gas and power price coupling, the UK's power price are still correlated with gas prices. The report highlights some decoupling over the analysed period, with calculated gas coupled price hours decreasing from 93% to 76%.

The programme has cost €12.7 billion net since 2017, including the revenues seen for the programme due to the clawback mechanism during the energy crisis. Last year the CfD scheme cost €2.5 billion.

To get a sense of this number, the report presents the number divided with the total demand in the UK 2025. For Onshore, Offshore and Solar PV the total cost for the CfD scheme then amounts to roughly 10 €/MWh. The report's modelling shows that the UK's prices today are on average 13 €/MWh lower than they would be without CfD capacities, which can be put into relation with the annual cost of 10 €/MWh.

Key facts of the UK power market (2017-2025)[1]

CfD based generation 2025	27 TWh
CfD based capacity 2025	Offshore 9.4 GW Onshore 1.4 GW Solar PV 1 GW
Carbon grid intensity[2] 2017 vs. 2025	2017: 303 gCO_2/kWh 2025: 174 gCO_2/kWh
Gas price setting hours 2017 vs. 2025	2017: 93% 2025: 76%
Total cost CfD programme 2025	€2.5 billion
CfD cost per total demand 2025	Offshore 9.3 €/MWh Onshore 0.3 €/MWh Solar PV 0.0 €/MWh
Modelled spot price reduction 2025	All CfD scenario: -13 €/MWh

[1] All prices and costs are inflation adjusted to 2026 price levels. Includes Offshore, Onshore, Solar PV, and Nuclear only. Full project capacity, even for partial CfD coverage, included., [2] Electricity Maps

3

Scenarios for potential CfDs in Sweden 2040

Modelling Sweden 2040

Demand scenario broken down by category

Understanding the demand growth

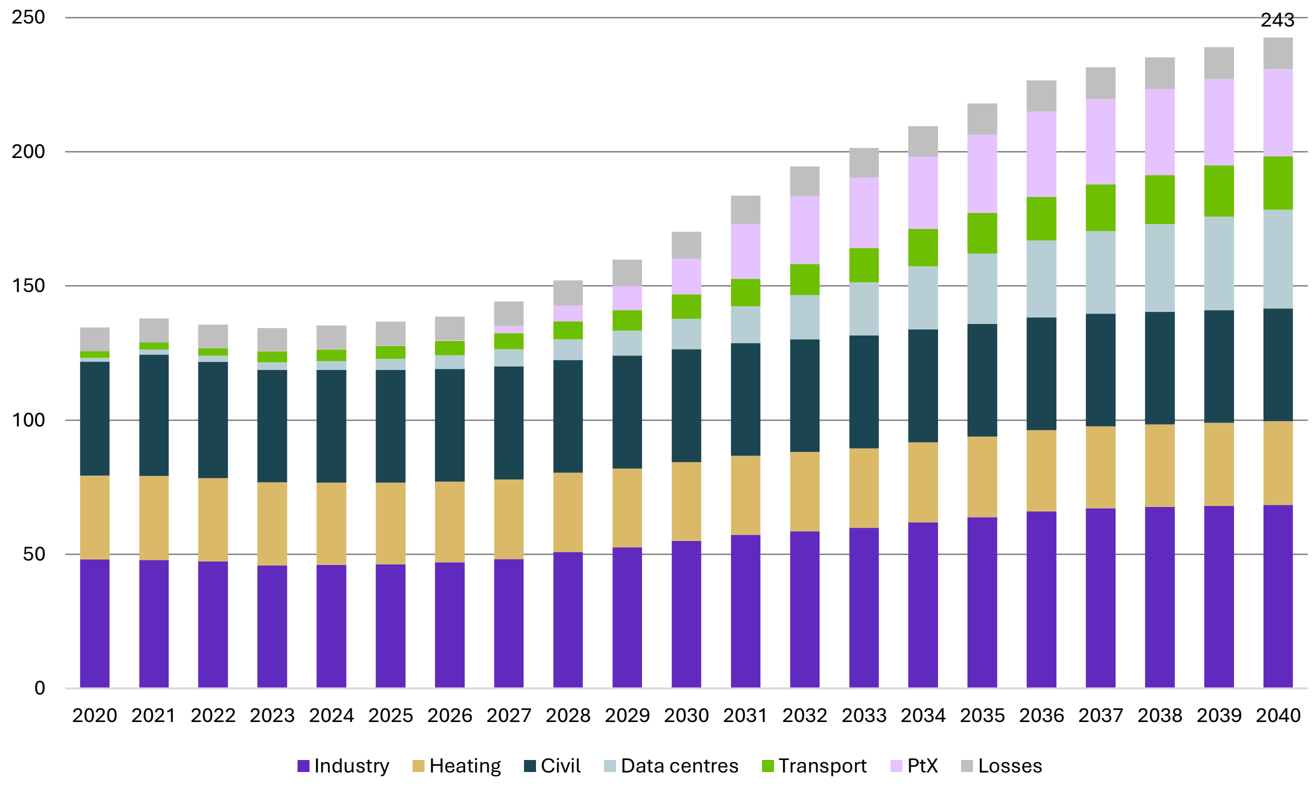
In this report a model of the Swedish spot market in 2040 is used to study the impact that different CfD schemes would have on the Swedish market prices as well as the profitability of existing unsubsidised actors. The year 2040 was chosen as it represents a point sufficiently far out in time for new demand to have grown enough to motivate new generation capacity. CfD-supported technologies could also realistically be commissioned by then. Further, it is sufficiently close in time that planning for new generation capacity must begin soon.

The scenario is in line with the government's planning target for an increased electrification and green transition[1]. The current ambition is to allow for an electricity demand of 300 TWh/y by 2045. The increase in demand can mainly be separated into four parts:

- Electrification of processes in existing industries;
- Build-out of data centres;
- Electrification of transport;
- And power-to-x applications.

The model is based on QC's inhouse power market model that incorporates northern Europe. Prices and dispatch are modelled on an hourly basis to catch weather volatility, but we mainly present yearly averages here.

Demand scenario used in modelling (TWh)



[1] Swedish government

Capacity and generation

The reports models four scenarios relating to a potential CfD scheme in Sweden

Scenarios chosen for the modelling

Four different CfD scenarios are analysed in this study:

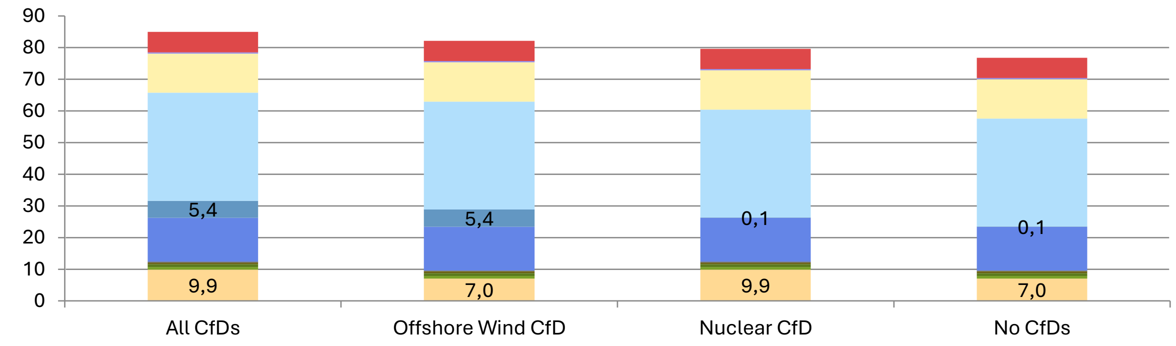
- **All CfDs:** CfD scheme for both new nuclear and offshore wind.
- **Offshore Wind CfD:** CfD scheme for only offshore wind.
- **Nuclear CfD:** CfD scheme for only nuclear.
- **No CfDs:** No CfD scheme.

In the **Nuclear scheme**, 2820 MW is added to the power system, representing six 470 MW Rolls-Royce SMRs, which is the type planned to be added by Vattenfall at Väröhalvön. The capacity is placed entirely in SE3. A capacity factor of 89% is assumed, resulting in a generation of 22 TWh/y.

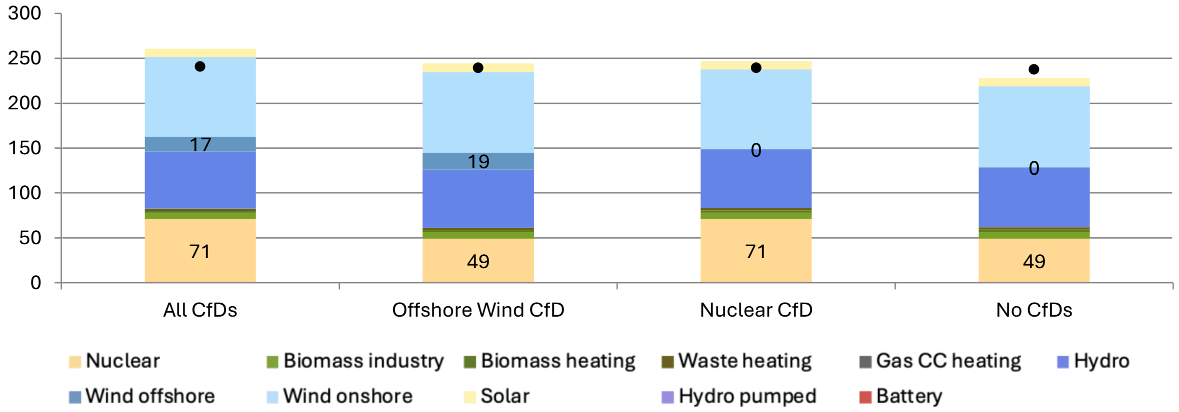
In the **Offshore scheme**, 5340 MW is added to the power system. This capacity was chosen to match the yearly generation in the nuclear scenario. A capacity factor of 47% was assumed, which roughly corresponds to new Danish offshore windfarms. The capacity is placed fully in SE3 to provide a clear comparison to the Nuclear subsidy scenario. The report acknowledges that the timeline to introduce the mentioned capacities is aggressive and might not be realistically realised by 2040, but it serves as an illustrative example.

Onshore wind power is assumed to have an upper capacity limit of 34 GW by 2040. This limit is set to take into account build out rate limitations, conflicts for land use and public acceptance. Including retirements of existing wind farms, this represents about 20 GW of new or repowered capacity depending on the assumed lifetime of existing wind farms. This amounts to 1.4 GW/y between 2026 and 2040, which can be contrasted to the average build out rate between 2012 and 2026, which was 1.1 GW/y.

Installed capacity per resource and scenario (GW)[1]



Generation per resource and scenario (TWh)[2]



[1] Battery capacity is the capacity assumed to be present on the spot market. [2] Note that offshore wind in the ”All CfD” scenario curtails 2 TWh/y due to low prices

Prices and volatility

Reviewing the scenarios implication on spot prices

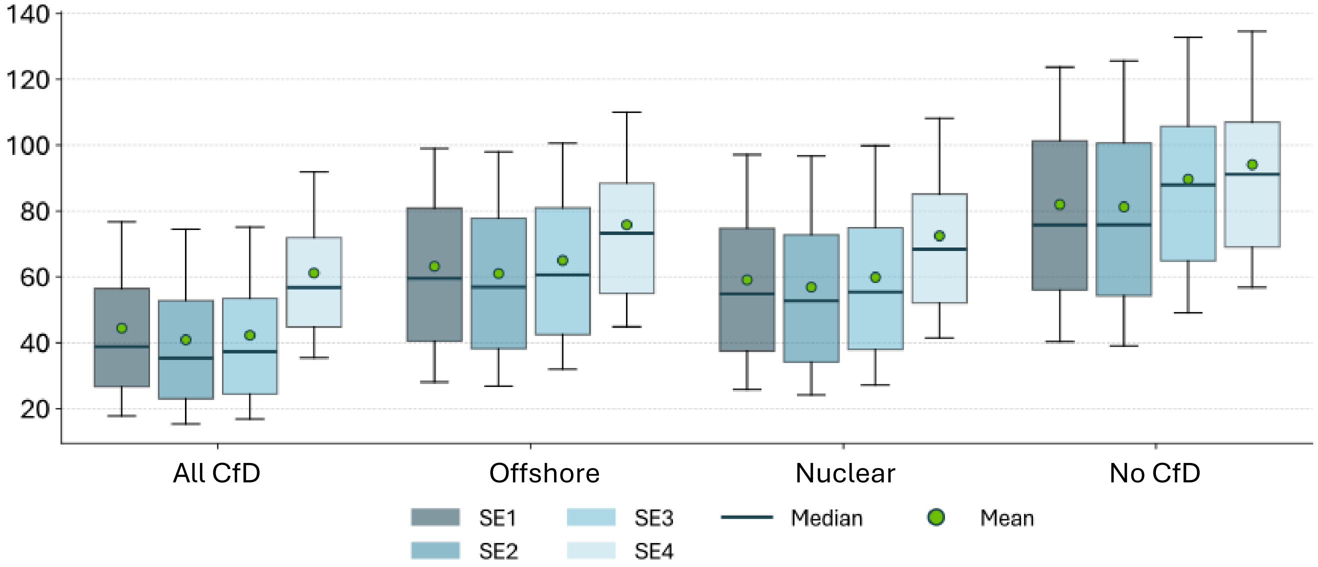
Background to the results

In the studied scenarios, the limitation of the onshore wind power capacity at 34 GW plays an important role for the resulting price formation. With this cap and no CfD based generation, Sweden is forced to become a net importer of electricity by 2040, with a negative power balance of about -10 TWh per year. This results in significantly higher prices than today at levels around 80-90 €/MWh. The realism in such a scenario could be questioned as the demand would likely not materialise at these prices. However, despite the high price levels, neither offshore wind power nor new nuclear power is competitive given bidded costs in recent auction rounds.

Instead, introducing additional generation capacity outside the spot market using a CfD mechanism can turn the power balance positive and lower the average prices compared to the reference scenario. The modelling suggests that reductions around 25 to 31 €/MWh can be achieved by adding 22 TWh/y of additional generation capacity with offshore wind power or new nuclear power. The price reduction is slightly larger when nuclear power is used, even though the yearly generation potential is the same. This is a result of the "baseload" generation profile, reducing the price coupling with the continent during strained hours.

Adding both technologies, with a combined generation potential of 44 TWh per year, could reduce the spot prices to levels in the mid 40s, which is comparable to today's prices.

Modelled prices per scenario (€/MWh)[1]



Modelled average prices per scenario (€/MWh)

	All CfD	Offshore	Nuclear	No CfD
SE1	45	64	60	83
SE2	42	62	57	82
SE3	43	66	60	91
SE4	62	77	73	95

[1] The boxes represent the spread of yearly average prices of 33 different weather years.

CfD costs

Offshore and Nuclear scenarios display similar results on total CfD cost

Comparing spot price reductions with CfD costs

Introducing generation capacity financed by CfDs lowers the prices by up to 31 €/MWh as the system moves from net importer to net exporter. However, the cost of the CfD must be added for a fair assessment. To present an example case, strike prices at 110 €/MWh and 150 €/MWh for offshore wind power and nuclear power, respectively, have been analysed. This is in line with actual auction rounds in new markets.

Despite the assumed higher strike price for nuclear power, the modelled annual cost of the CfD is roughly the same, at about 1.9 B€/y. This is a result of the different capture rates of the resources. While nuclear runs as "baseload" generation and receives the average price (capture rate = 1.0), wind power generation is negatively correlated with prices, and receives a lower-than-average price. In these scenarios, the resulting capture rate of offshore wind is 0.7. For comparison, actual capture rates of onshore wind power in the Swedish bidding zones have fluctuated between 0.5 and 0.83 since 2023.

Spread out over the total demand, the costs for the CfDs in this example sum to a little less than 8 €/MWh. This is several times lower than the spot price reduction of up to 31 €/MWh, highlighting a main property of the CfD, namely, that not all producers need to receive the cost of the most expensive producer.

When introducing subsidised capacity outside the free market, care needs to be taken to not push out competing unsubsidised actors. In this example, a clear reduction in captured prices for existing onshore wind power can be seen, down from 62 €/MWh without the CfD to about 40 €/MWh with any of the CfD schemes. In the scenario "All CfD", the captured prices fall to alarmingly low levels of 24 €/MWh, indicating an overproduction with respect to demand.

CfD cost for a conventional two-sided CfD[3]

	Offshore	Nuclear
Scenario spot price reduction (€/MWh)	-25	-31
Strike price (€/MWh)	110[1]	150[2]
Capture rate (au)	0.7	1.0
Annual CfD cost (B€)	1.84	1.91
CfD cost per total demand (€/MWh)	7.6	7.8

Capture prices & rate for onshore wind (€/MWh, %)

	All CfD	Offshore	Nuclear	No CfD
SE1	29 (64%)	42 (66%)	41 (68%)	57 (69%)
SE2	26 (62%)	38 (62%)	39 (68%)	55 (67%)
SE3	24 (56%)	39 (59%)	39 (65%)	62 (68%)
SE4	37 (60%)	48 (62%)	48 (66%)	67 (71%)

[1] Estimate based on recent Offshore CfD rounds in Europe, [2] Based on inflation adjusted values from Hinkley Point C [3] Modelled according to the recent Danish capability based CfD design

System support

Planning for the future requires a complete system perspective

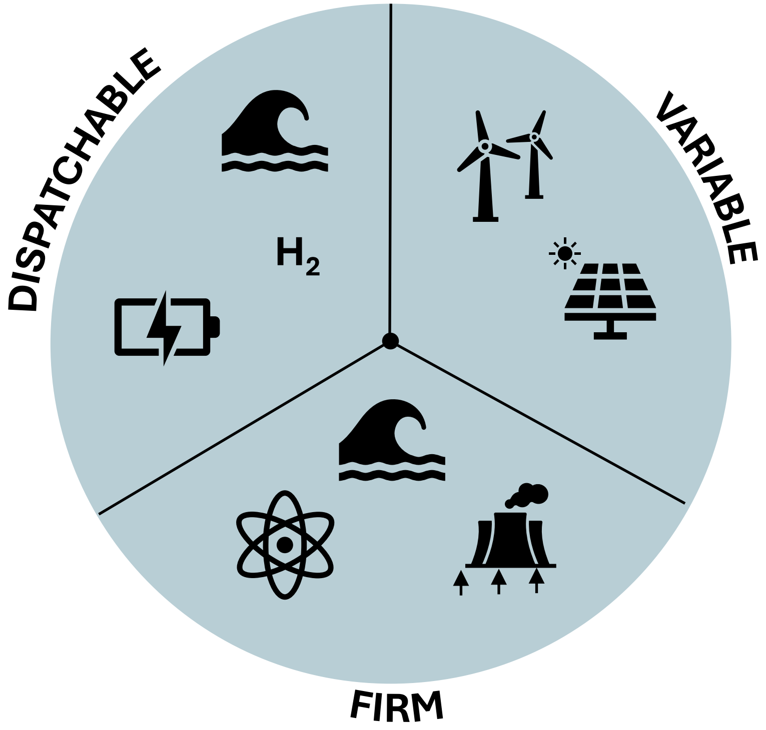
CfDs from a system perspective

A conventional two-way CfD operates fundamentally as a per-MWh compensation mechanism, calibrated to plant-level LCOE and rewarding energy volume. However, this framing is insufficient as a basis for technology evaluation in a transitioning system. Cost-effective electricity systems are created with a balance of technology roles, as illustrated by the dinner plate model (figure to the right). Variable renewable energy sources, including onshore and offshore wind and solar, provide abundant low-cost energy during favourable conditions, while dispatchable technologies, including hydropower, gas turbines, and storage, underpin balancing and flexibility. Firm resources, notably nuclear and thermal generation, ensure resource adequacy and the system stability services that variable generation alone cannot reliably supply[1].

A direct comparison of CfD support levels between firm generation and variable renewables is therefore analytically incomplete unless the full system integration cost is accounted for, encompassing profile, balancing, grid, and ancillary service costs, and the system service contribution of firm capacity is correspondingly recognised[1]. The fairness of this comparison is further conditioned by the existing system into which new generation is introduced: in the Nordic context, flexible hydropower already absorbs substantial variability, reducing the system value of additional firm capacity. Notably, VRE technologies combined with complementary assets, including synchronous condensers, gas turbines, and battery storage, can increasingly replicate system stability capabilities. It is only when this full portfolio cost is evaluated between alternatives that a rigorous basis for CfD design comparison emerges.

Dinner plate model of the technology mix

For a robust and balanced electricity system.



[1] UNECE

How technology and location matter

A CfD design should harmonise with SvK's long term planning

A CfD needs to be aligned with SvK's goals

The Swedish government has given Svenska kraftnät[1] the responsibility of planning for a secure and reliable electricity system (leveranssäkert elsystem) that is compliant with the national reliability standard (tillförlitlighetsnorm). SvK has concluded[2] that the risk of capacity shortage falls when new generation in an area keeps pace with the growth in local consumption. Different technologies, however, reduce the risk to different degrees depending on their ability to supply power during strained periods. Notably, capacity shortfalls during strained periods can also be mitigated through demand-side flexibility and storage resources.

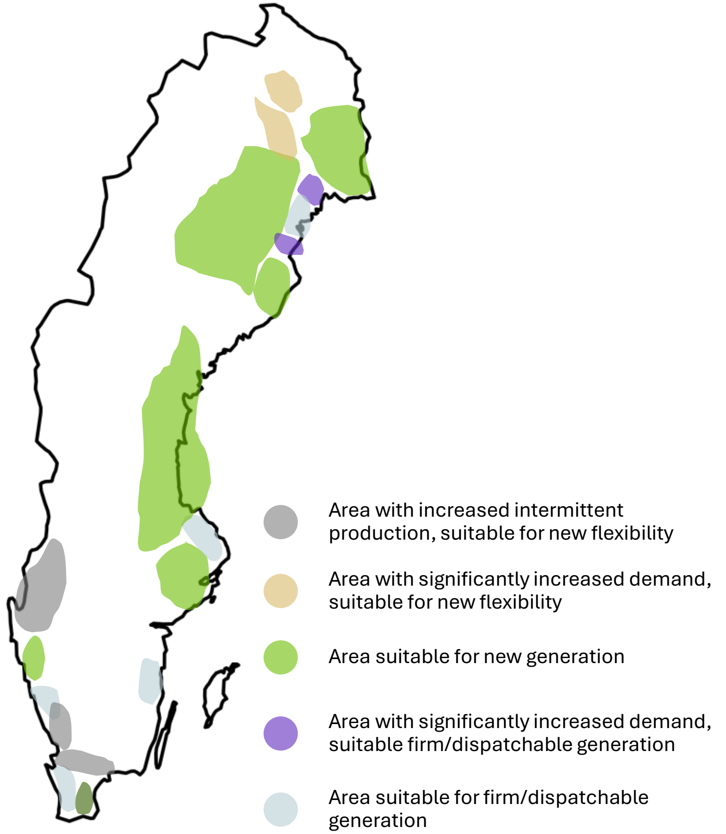
SvK has analysed[3] how the derating capacity factor differs between technologies, i.e., how much of the installed capacity that is expected to be generating for at least 90% of the time during strained periods. The resulting values span the range from 84% for hydro power to 11% for onshore wind. Assuming the capacities considered in this report this allows for about 1 GW new demand in the offshore scenario and 2 GW in the nuclear scenario. Combining technologies, for example offshore wind power with gas or long-term storage, could increase these numbers.

To improve transparency and reduce grid connection lead times, SvK has begun[4] identifying areas suited to specific resource types, guided by four principles: 1) new generation should be located in areas with a supply deficit, 2) firm generators should be located close to low-flexibility demand, 3) non-firm generation should be located close to flexible demand, and 4) new industries should be more flexible and align with available supply.

Given the already constrained grid connection process, expanding energy supply without accounting for system integration requirements risks a suboptimal system design. Therefore, a CfD design should support the overarching target to enable growing demand, and it should be carefully aligned with SvK's responsibility to orchestrate a long-term plan for the power system.

	Onshore	Offshore	Nuclear	Gas	Hydro
Derating capacity factor[2]	11%	18%	74%	74%	84%
New possible demand outtake in CfD scenarios	-	961 MW	2087 MW	-	-

SvK map to direct new investments



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Discussion and conclusions

Analysis UK CfD scheme

Lessons learned from the UK CfD scheme

The UK CfD scheme's core goal is to lower the cost of capital for low-carbon technologies by removing risk and enabling the rapid expansion of generation needed to meet climate targets. This form of subsidy has been chosen to achieve this in the most cost-effective way for consumers. In this measure, the scheme has worked: CfDs enabled rapid renewable expansion, keeping spot prices lower than they would otherwise have been after coal capacity was fully decommissioned in 2024.

A dedicated counterparty makes the contract bankable. The UK uses a public company (the LCCC) to hold and settle CfDs, funded by a statutory levy on suppliers, so lenders underwrite the contract rather than the fiscal position of the current or future government. Confidence is reinforced by a design that keeps contracts stable while allowing auctions to be flexible: signed CfDs are honoured, while allocation parameters are tweaked each round to adapt to the state of the market.

Annual rounds build supply chains. As visible pipelines let developers and manufacturers invest, this can in turn lower future bids over time. Technology-banded pots can open the door for maturing technologies, and they can help to add the type of generation that is needed most in a diverse energy mix.

The relatively simple two-sided payment has proven its worth. As seen in 2022, in times of crisis the CfD generators pay back into the system. The UK government has, nevertheless, acknowledged the benefits of more contemporary CfD designs than what they have used so far. While payment is tied to metered output rather than system value, subsidised generators are largely insulated from price signals: curtailment at zero can introduce cliff-edges, there is little incentive to offer balancing services or co-locate with storage or a flexible load, and dispatch decisions can be distorted as a result.

A single national strike price says nothing about where generation is useful. With no location-specific pots, and payment tied to volume generated rather than availability, capacity can cluster in locations where the network cannot absorb it, and optimal dispatch decisions may not be taken. Basing payment on availability, rather than output, could incentivise better siting. Additionally, winning a CfD does not secure a grid connection. Connection and planning risk stays with the developer, so awarded capacity can stall behind queues. A possible solution could be to bundle connection into the award.

As the contracted share grows, unsubsidised investments may become harder to finance. Delinking payment from metered output via CfD design, combined with contracting only a percentage of an asset's capacity, can restore exposure of subsidised generators to market signals. This exposure can help to limit distortive dispatch decisions which erode unsubsidised generators' revenues.

It is not just the design choice, but the details that make a difference, as exemplified with the UK price caps in AR5, which were set too low with respect to costs and led to zero offshore wind bids. Of course, high prices would be unacceptable to consumers, so a competitive landscape is needed to attract multiple bids that land lower than a sensible cap.

There is room for improvement in the UK CfD framework, but the fact remains that this scheme has already delivered an enormous build-out of renewable capacity. When an ambitious build-out is a priority, **acting and iterating is more important than waiting for the perfect design**. Even if a more sophisticated design had been chosen from the start, the rapidly changing market would still demand revisions, for example, an increasing frequency of negative prices. This model of annual rounds and openness to frequent analysis and tweaking is therefore a key takeaway for any prospective CfD schemes.

A path forward for Sweden

Nuclear and offshore wind power have similar costs and power market impacts

The purpose of this study has been to present a realistic pathway for the Swedish electricity system in line with the government's goal of enabling a doubling of the demand. This and several other studies conclude that the primary technology for supplying energy to the system, and therefore keeping prices competitive, will be onshore wind power as it has the lowest cost of production. However, the expansion of onshore wind risks facing growing resistance, and its capability to enable a significant demand growth is also limited unless it is complemented with other measures. For this reason, onshore wind expansion is capped at 34 GW by 2040 in this report. With a demand that reaches 243 TWh by 2040, prices increase significantly, presenting a situation that is not realistic from a consumer perspective.

Therefore, this study has modelled and analysed the impact on spot market prices of a CfD scheme supporting two different technologies, nuclear and/or offshore wind. We find that introducing about 22 TWh/y of either nuclear or offshore wind power in SE3 has the potential to reduce spot prices by 25–31 €/MWh, resulting in a more attractive environment for investments in the electrification of industry and society. The differences in impact on the power market between nuclear and offshore wind are small, with a minor advantage for nuclear: assuming the same yearly production, adding nuclear power results in slightly lower average spot prices and less cannibalisation with unsubsidised onshore wind power**.**

A CfD comes with a cost for society. This will in one way or another be transferred to consumers or taxpayers. This study nevertheless concludes that the cost can be significantly smaller than the potential electricity cost reduction, if the CfD cost is spread across the whole consumer collective. Examining CfD auctions in other countries, a picture emerges where offshore wind projects generally have a lower strike price than nuclear power. But once the differences in capture rate of the two technologies are included, which the model calculates to be around 70% for offshore wind power in 2040, the resulting costs of the CfDs are about equal.

Maintaining the profitability of unsubsidised technologies, such as onshore wind power or lifetime extensions of existing nuclear power, is vital for a competitive system. Care needs to be taken to ensure that subsidised generation does not push out unsubsidised generation. The modelling highlights this risk in the "All CfD" scenario, where about 44 TWh per year is added and captured prices for existing onshore wind power fall far below a profitable level. In such a case, support would need to be given also to established technologies, reducing the overall competitiveness of the system.

The modelling presented here only concerns the spot price market and does not consider the ability of new loads to be connected to the grid. Sweden has faced a growing number of industries wanting access to the power grid, and both SvK and the DSOs communicate that the build-out of transmission lines is a bottleneck that will take years to overcome. The overarching goal for a CfD design should therefore be to support a growing demand while realising the lowest possible cost. Simply supplying more energy is not enough; what system contribution will be delivered, and in what location, is equally important.

A path forward for Sweden (continued)

Aspects to consider in a potential Swedish CfD design

Locating generation in grid-constrained areas could have a positive impact on the timeline and the possibility of connecting new demand. For that positive impact to be realised the technical characteristics of the generator may also matter. The CfD design could therefore apply both geographical and technical components to ensure that any supported generation contributes to connecting new demand. Alternatively, a CfD could be designed around a targeted system benefit, i.e. enabling more demand to be connected to the grid. Schlecht et al. mention a version of a financial CfD that places baseload-based obligations on generators; such a CfD would incentivise firm generation, or intermittent generation combined with other technologies, which deliver the same profile. This could for example be offshore wind power together with gas turbines or large storage. Any CfD design should also secure incentives for adequate dispatch and for operating the asset in line with price signals: in situations of negative prices there should be incentives to lower output and/or curtail.

On cost, a design allowing participants to bid, i.e. an auction mechanism, could increase competition and thereby lower cost compared to a situation where the CfD contract is agreed bilaterally. To increase the number of participants, a technology-neutral design could be applied, but since different technologies have different requirements a combined approach is likely required, where parts of the support design are shared while others are technology- and stakeholder-specific. Such a design choice should for obvious reasons be based on a thorough analysis.

A CfD could serve as the only risk-reducing instrument or be combined with others, as in the current nuclear programme, which combines a CfD with state-backed financing and project risk reduction; in combination it is expected that the strike price should be lower and the total cost distributed over several components. It should also be noted that a simpler and more transparent CfD design likely reduces the risk of introducing unintended biases towards specific technologies or participants.

There are also potential adverse consequences. Any CfD-supported project has reduced or removed its market risk, meaning there are no incentives to hedge the output through other instruments such as the financial market or PPAs. This might decrease buyers' possibilities for hedging, reducing liquidity in both financial and bilateral markets, and the negative implications increase with volume. New industrial projects with large power demands are often required to reduce their risk exposure to secure financing, using PPA contracts and similar instruments. To mitigate this negative impact, requirements to sell volumes could be added to the design, either through the asset owner or through the body managing the CfD regime.

Finally, as illustrated by the scenario modelling, a mismatch between demand and CfD volumes could establish a large oversupply, pushing prices down to critically low levels for any non-subsidised power that must maintain its cash flow and, in the long run, its financial stability. Therefore, as in the UK CfD design, check points should be included in the overall design, allowing for the ambition to be adjusted.